# ATTACHMENT (10)

## TRANSNUCLEAR CALCULATION NO. 1095-49 –

## NON-PROPRIETARY VERSION

**Calvert Cliffs Nuclear Power Plant, LLC**
**March 9, 2011**

| ESP No.: | ES200100653 | Supp No. | 000 | Rev. No. | 000 | Page 1 of 1 |
|---|---|---|---|---|---|---|

## FORM 19, CALCULATION COVER SHEET

**A. INITIATION** (Control Doc Type - DCALC) Page 1 of

DCALC No.: CA06292 Revision No.: 0000

Vendor Calculation (Check one): ☒ Yes ☐ No

Responsible Group: Fuel Operations Support Unit

Responsible Engineer: John R. Massari

**B. CALCULATION**

ENGINEERING DISCIPLINE: ☐ Civil ☐ Instr & Controls ☒ Nuc Engrg ☐ Electrical ☐ Mechanical ☐ Nuc Fuel Mngmt ☐ Other: ☐ Reliability Engrg

Title: NUHOMS 32P RADIATION DOSE RATES FOR LOADING AND TRANSFER

Unit ☐ 1 ☐ 2 ☐ COMMON

Proprietary or Safeguards Calculation ☐ YES ☒ NO

Comments:

Vendor Calc No.: 1095-49 REVISION NO.: 0

Vendor Name: TRANSNUCLEAR, INC.

Safety Class (Check one): ☒ SR ☐ AQ ☐ NSR

There are assumptions that require Verification during walkdown: AIT #:

This calculation **SUPERSEDES:**

**C. REVIEW AND APPROVAL:**

| | | |
|---|---|---|
| Responsible Engineer: | Transnuclear, Inc. | 8/29/03 |
| | Printed Name and Signature | Date |
| Independent Reviewer: | John. R. Massari | 10/10/03 |
| | Printed Name and Signature | Date |
| Approval: | N/A | |
| | Printed Name and Signature | Date |

**IF the results or conclusions of this calculation or revision might affect a procedure or the basis of a procedure, a Change Notification Form (Form 14) shall be forwarded to the Procedure Development Unit with a summary of the calculation's purpose and results.**

TRANSNUCLEAR

**Form 3.1-1**
**Calculation Approval Sheet**

**Project Name:** NUHOMS®-32 P (NUHOMS® for Calvert Cliffs) **Project #:** 1095

**Calculation Title:** NUHOMS®-32 P - Radiation Dose Rates for Loading and Transfer

**Calculation #:** 1095-49 **Draft/Revision #:** 0 **DCR #:**

**Number of pages:** 16

**Number of CDs attached:** 0 **Files for this calc are included in the CD attached to Calc 1095-50**

**If original issue, 10CFR72.48 review required?**
**[X] No (explain)** **[ ] Yes, SR No.**

**This calculation is intended to support either a 72.48 review by the holder of a site-specific license, or an amendment application for that license. Therefore, a 72.48 review by Transnuclear is not applicable.**

1. **This calculation is complete and ready for independent review**

   Originator's Signature A. Prakash Date: 08/25/2003

2. **This calculation has been checked for consistency, completeness, and arithmetic correctness.**

   Checker Signature M Mian Date: 8/26/03

3. **Calculation preparation and check complies with procedure - package is complete**

   PE's Signature Glenn Grewe Date: 8/29/03

## 1.0 Purpose

To calculate the radiation dose rates (photon and neutron) at various locations around the NUHOMS®-32P DSC (basket plus canister) for Calvert Cliffs ISFSI. These values are estimated prior to the placement of the DSC inside the HSM. The NUHOMS®-32P basket is loaded with 32 CE 14x14, design basis, PWR spent fuel assemblies

## 2.0 References

2.1 Transnuclear Calculation 1095-01, rev. 0, NUHOMS-32P - Weight Calculations for the DSC/TC System.

2.2 MCNP4B2, "Monte Carlo N-Particle Transport Code System, " Los Alamos National Laboratory, CCC-660, RSIC

2.3 Letter from Robert H. Beall, Calvert Cliffs Nuclear Power Plant to Glen Guerra, Transnuclear, "Transmittal of Revised NUHOMS-24P Calculation for the CCNPP ISFSI", Letter No. NFM 02-002, dated 2nd January 2002.

2.4 Calvert Cliffs Calculation CA05803, rev. 0, ISFSI 24P Assembly Insertion Requirements.

2.5 Transnuclear Calculation 1095-48, rev. 0, Atomic Fractions for the Shielding Analysis of the NUHOMS-32P basket.

2.6 Duke Engineering and Services Calculation, CCNPP-DES-002, rev. 0, Calvert Cliffs ISFSI/NUHOMS-24P Radiation Dose Rates for Cask Loading and Transfer.

2.7 Calvert Cliffs ISFSI USAR, Rev. 8

2.8 BGE Engineering Evaluation No. ES200200585, "Evaluation of the Shielding Source Terms for the ISFSI-32P Phase I Design "

2.9 NRC Certificate of Compliance No. 9293, Rev. 1 for the TN-68 Transport Package, Docket No. 71-9292, dated March 14, 2001.

2.10 NRC Certificate of Compliance No. 9302 for the NUHOMS®-MP197 Transport Package, Docket No. 71-9302, dated July 11, 2002.

## 3.0 Methodology, Design Inputs and Assumptions

### 3.1 Methodology

The radiation dose rates for a single NUHOMS® DSC for Calvert Cliffs ISFSI with the 32P basket are determined in this calculation. These dose rates are estimated prior to loading of the DSC within the HSM. The current analysis of record for the dose rate estimates is documented in Ref. [2.6] for the 24P basket. The dose rates are also reported in the ISFSI USAR (Ref [2.7]). The radiation dose rates from this calculation will be added in the USAR for the 32P basket in addition to those for the 24P basket.

The three-dimensional, Monte Carlo particle transport computer code, MCNP, Version 4B, Ref. [2.2] has been utilized to calculate the dose rates. This version of the MCNP computer code has been utilized by Transnuclear for shielding evaluations and has been approved by the NRC as shown in Ref. [2.9] and Ref. [2.10].

The various operations (dose calculation points) associated with cask loading and transfer are documented in Ref. [2.6] and the same are analyzed in this calculation package. The results of these dose rate calculations are compared those reported in Ref. [2.6].

### 3.2 Design Inputs

The design basis fuel assembly for this calculation is the CE 14x14 fuel assembly with an initial enrichment of 3.4 wt% U-235, a burnup of 42 GWD/MTU and cooled to 8 years. The photon and neutron source terms for this fuel assembly have been determined and are reported in Ref. [2.6]. These source terms are also utilized in Ref. [2.6]. For the purpose of this calculation, the source terms are obtained directly from Ref. [2.4] and Ref. [2.6]. The source terms relevant to this calculation are shown in the following tables:

Energy PDF for the Neutron Source Term

| Energy Range (MeV) | Neutron Source (n/sec/assy) | | Energy Probability |
|---|---|---|---|
| | Design Basis[1] | Utilized in Calc. | |
| 6.3600 - 20.000 | 9.024e+06 | 6.150e+06 | 0.0270 |
| 3.0100 - 6.3600 | 6.636e+07 | 4.523e+07 | 0.2010 |
| 1.8300 - 3.0100 | 7.407e+07 | 5.048e+07 | 0.2240 |
| 1.1100 - 1.8300 | 6.891e+07 | 4.696e+07 | 0.2090 |
| 0.5500 - 1.1100 | 6.342e+07 | 4.322e+07 | 0.1920 |
| 0.1100 - 0.5500 | 4.377e+07 | 2.983e+07 | 0.1330 |
| 0.00335 - 0.1100 | 4.437e+06 | 3.024e+06 | 0.0130 |
| **Total** | **3.300e+08** | **2.249e+08** | |

Note: 1) The Design basis source term is documented in Ref. [2.8].

The source term utilized in this calculation is similar to the design basis source term with the same energy spectrum. [redacted]

PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

Energy PDF for the Active Fuel Gamma Source Term

| Energy (MeV) | Energy Probability |
|---|---|
| 0.1250 | 0.50080 |
| 0.2250 | 0.03949 |
| 0.3750 | 0.02103 |
| 0.5750 | 0.74084 |
| 0.8500 | 0.10422 |
| 1.2500 | 0.04339 |
| 1.7500 | 0.00089 |
| 2.2500 | 0.00006 |

Axial Source Term Probability Function (for both Photons and Neutrons)

| Axial Region | Axial Location (cm) | Neutron Activity (n/s) in DSC | Axial Probability | Photon Activity (γ/s) in DSC | Axial Probability |
|---|---|---|---|---|---|
| Bottom Nozzle | -12.7 | | | | |
| Active Fuel | 0 | | | 2.715e+14 | 0.00447 |
| 1 | 8.89 | 1.191e+07 | 0.00199 | 8.821e+14 | 0.01453 |
| 2 | 26.7 | 1.226e+08 | 0.02052 | 2.533e+15 | 0.04173 |
| 3 | 49.5 | 3.534e+08 | 0.05918 | 3.950e+15 | 0.06507 |
| 4 | 297.8 | 5.057e+09 | 0.84680 | 4.585e+16 | 0.75546 |
| 5 | 320.5 | 3.197e+08 | 0.05354 | 3.859e+15 | 0.06357 |
| 6 | 338.3 | 9.941e+07 | 0.01664 | 2.408e+15 | 0.03967 |
| 7 | 347.2 | 7.918e+08 | 0.00133 | 8.035e+14 | 0.01234 |
| 1 | 370.9 | | | 1.146e+14 | 0.00189 |
| 2 | 375.9 | | | 7.651e+12 | 0.00013 |
| 3 | 386.1 | | | 1.471e+13 | 0.00024 |
| | **Total (24P)** | **5.972e+09** | **1.00000** | **6.070e+16** | **1.00000** |
| | **Total (32P)** | **7.963e+09** | **1.00000** | **8.093e+16** | **1.00000** |

Note that the neutron and photon activities (particles/sec/DSC) for the 32P basket have been directly scaled from those of the 24P basket. Comparing the neutron activity in the DSC (5.972e+09 n/sec for 24 fuel assemblies) to that of an individual fuel assembly (2.249e+08 n/sec), it is noted that the axial peaking in the DSC is about 1.107 (5.972 e+09/(2.249e+08*24)). This means that the neutron source strength in the DSC, if defined based on an assembly basis, is under-predicted by a factor of 1.107. In order to include the effect of axial peaking, the neutron and capture gamma dose rates are scaled up further by a factor of 1.107.

PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

The basic MCNP model for the calculation is obtained from Ref. [2.6]. In this calculation, the Ref. [2.6] model is modified to include the NUHOMS®-32P basket instead of the 24P basket. All the computer cases documented in Ref. [2.6] are re-analyzed with MCNP-4B, this time with the 32P basket design. Therefore, the computer input files utilized in this calculation are identical to those documented in Ref. [2.6] except:

- The basket design is changed to the NUHOMS 32P with the modified fuel / basket homogenization documented in Ref. [2.5].
- In addition, the basket is also divided into three radial zones - fuel / basket zone (radius = 80.15 cm), Aluminum-rail shell zone (thickness = 1.21 cm) and Stainless steel-rail shell zone (thickness = 1.19 cm).
- Source term multiplication factor is changed from 24 (for the 24 fuel assemblies) to 32 (for the 32 fuel assemblies) per DSC.

The material specifications in the MCNP model are changed as follows. The atomic fractions are calculated in Ref. [2.5] and are shown in the following tables

PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

Stainless Steel : Material No. = 2, Density = 7.940 g/cm$^3$

| Nuclide ID | Mass Fraction | Nuclide ID | Mass Fraction |
|---|---|---|---|
| 24000 | 0.19000 | 25055 | 0.02000 |
| 26000 | 0.68375 | 28000 | 0.09500 |

Dry Air : Material No. = 3, Density = 0.0012 g/cm$^3$

| Nuclide ID | Mass Fraction | Nuclide ID | Mass Fraction |
|---|---|---|---|
| 7014 | 0.75519 | 8016 | 0.23179 |
| 6000 | 0.00014 | 18000 | 0.01288 |

Bottom Zone, Dry : Material No. = 8, Density = 1.166 g/cm$^3$

| Nuclide ID | Atomic Fraction | Nuclide ID | Atomic Fraction |
|---|---|---|---|
| 13027 | 0.09932 | 24000 | 0.18407 |
| 25055 | 0.01834 | 26000 | 0.61674 |
| 28000 | 0.08154 | | |

Aluminum Rails: Material No. = 10, Density = 2.702 g/cm$^3$

| Nuclide ID | Atomic Fraction | Nuclide ID | Atomic Fraction |
|---|---|---|---|
| 13027 | 1.0000 | | |

Plenum Zone, Dry : Material No. = 11, Density = 0.951 g/cm$^3$

| Nuclide ID | Atomic Fraction | Nuclide ID | Atomic Fraction |
|---|---|---|---|
| 40000 | 0.02768 | 13027 | 0.12267 |
| 24000 | 0.17364 | 25055 | 0.01730 |
| 26000 | 0.58180 | 28000 | 0.07692 |

Top Fitting Zone, Dry: Material No. = 12, Density = 1.017 g/cm$^3$

| Nuclide ID | Atomic Fraction | Nuclide ID | Atomic Fraction |
|---|---|---|---|
| 13027 | 0.11320 | 24000 | 0.18123 |
| 25055 | 0.01805 | 26000 | 0.60723 |
| 28000 | 0.08028 | | |

All the material properties are based on dry conditions. For calculations involving the cask with fuel assemblies immersed in the spent fuel pool, the atomic fractions calculated in Ref. [2.5] are used. It is assumed that the soluble boron concentration in the spent fuel pool is 1800 ppm.

The flux-to-dose conversion factors for neutron and gamma radiation are directly obtained from Ref. [2.6] and the same factors have been utilized in these calculations.

3.3 Assumptions

1) The Stainless steel and Aluminum rails of the basket are modeled as cylindrical shells surrounding the homogenized fuel-basket regions. [redacted]
PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

2) [redacted]
PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390
This homogenization is expected to conservatively predict the radial dose rates and adequately predict the axial dose rates.

3) The composition of Stainless steel by weight percentage is assumed to be - Chromium 19.0%, Manganese 2.0%, Iron 68.375% and Nickel 9.50%.

4) Zirc-4 in the fuel assemblies is homogenized as Zirconium metal and Inconel is homogenized as Stainless steel.

5) For wet conditions, the soluble boron concentration in water is assumed to be 1800 ppm even though a higher soluble boron concentration is present in the pool during cask loading operations. Boronated water is modeled only in the active fuel zone.

## 5.0 Results

MCNP was utilized to perform shielding analysis of the NUHOMS®-32P DSC to determine the dose rates for loading and transfer. The results of the calculations are shown in Tables 5-1 through 5-6. Also shown in these tables are the Ref. [2.6] results for comparison. The case description and MCNP output file names are shown in Table 5-1

Table 5-1: MCNP output files names

| Target ID[A] | Configuration[B] | Case ID | Target Location (Work Activity) |
|---|---|---|---|
| C-1a | DSC in Cask, DSC and Annulus flooded 8" from top | 1 | Above Shield Plug on DSC axis |
| | | 2 | 1.5' above Shield Plug |
| | | 3 | 4.0' above Shield Plug |
| C-2.1 | DSC in Cask, DSC and Annulus dry, 3" NS-3 | 4 | Above Cover plate and 3" of NS-3 on DSC axis |
| C-2.2A | DSC in Cask, DSC dry, Annulus flooded | 5 | Above Cask on outer edge of annulus, Top of cask off |
| C-2.2B | DSC in Cask, DSC and Annulus dry | 6 | Above Cask on outer edge of annulus, Top of cask off |
| | | 7 | At 1.5' (based on larger detector volume than above tally) |
| C-2.2C | DSC in Cask, DSC dry, Annulus wet. no cover plate | 8 | 1.5' Above cask on outer edge of annulus, top of cask off |
| | | 9 | 4.0' Above cask on outer edge of annulus, top of cask off |
| C-3.1A | DSC in Cask, DSC and Annulus dry, Top of Cask on | 10 | 1" from side of Cask (normal) |
| | | 11 | 8' from side of cask (normal) |

Table 5-1 (contd..): MCNP output files names

| Target ID[A] | Configuration[B] | Case ID | Target Location (Work Activity) | | |
|---|---|---|---|---|---|
| C-3.1C | DSC in Cask, Accident, NS-3 on the side of the TC is replaced with air | 12 | 1" from side of Transfer Cask | | |
| | | 13 | 15' from side of Transfer Cask | | |
| C-3.2 | DSC in Cask | 14 | 1" above cask on axis | | |
| | | 15 | 1.5' above cask on axis | | |
| C-3.3 | DSC in Cask, Ram access open | 16 | 1" from bottom of cask | | |
| | | | | | |



Notes:

A The configuration target ID numbers are based in part on Table 7.3-1 in USAR

B Annulus refers to the annular gap between the outside of the canister and inside of the cask

C The file name formats for neutron is ****n.out and for gamma is ****p.out

D The file name formats for neutron *****n and for gamma is *****p

Table 5-2 shows the gamma dose rates based on the results of the shielding calculations for NUHOMS®-32P. The neutron transport calculations are analyzed as a coupled Neutron-Photon transport problem in MCNP. Thus, the Gamma results are shown under two separate categories -- direct and capture gamma tallies. Table 5-2 shows the direct gamma dose rates while Table 5-3 shows the capture gamma dose rates. The neutron dose rates are shown in Table 5-4.

Table 5-2: Gamma Dose Rates (from Direct Gamma Sources)

| Case No. | Tally No. | Results from Ref. (2.6) | | Results for NUHOMS®-32P | |
|---|---|---|---|---|---|
| | | **Dose Rate (mrem/hour)** | **Relative Error** | **Dose Rate (mrem/hour)** | **Relative Error** |
| 1 | 254 | 7.6270E+01 | 0.0874 | 8.5176E+01 | 0.0359 |
| 2 | 284 | 7.0911E+01 | 0.0924 | 7.5694E+01 | 0.0354 |
| 3 | 294 | 5.6508E+01 | 0.1030 | 5.7720E+01 | 0.0393 |
| 4 | 254 | 9.4707E+01 | 0.1328 | 9.4734E+01 | 0.0738 |
| 5 | 254 | 6.2185E+01 | 0.0917 | 6.4264E+01 | 0.0543 |
| 6 | 254 | 1.3634E+02 | 0.1395 | 1.3573E+02 | 0.0824 |
| 7 | 284 | 1.2085E+02 | 0.1293 | 1.2761E+02 | 0.0735 |
| 8 | 284 | 1.7528E+02 | 0.0604 | 1.9022E+02 | 0.0280 |
| 9 | 294 | 1.0001E+02 | 0.0650 | 1.1738E+02 | 0.0331 |
| 10 | 104 | 6.9759E+01 | 0.0256 | 4.3512E+01 | 0.0148 |
| 11 | 304 | 1.6490E+01 | 0.0277 | 1.0117E+01 | 0.0159 |
| 12 | 104 | 1.3335E+02 | 0.0151 | 8.1623E+01 | 0.0088 |
| 13 | 304 | 1.5706E+01 | 0.0166 | 9.4975E+00 | 0.0096 |
| 14 | 104 | 8.3423E-01 | 0.0404 | 8.7693E-01 | 0.0283 |
| 15 | 204 | 7.4378E-01 | 0.0405 | 7.7971E-01 | 0.0287 |
| 16 | 104 | 6.2882E+01 | 0.0576 | 7.3202E+01 | 0.0361 |

Table 5-3: Gamma Dose Rates (from Capture Gamma Sources)

| Case No. | Tally No. | Results from Ref. (2.6) | | Results for NUHOMS®-32P | |
|---|---|---|---|---|---|
| | | **Dose Rate (mrem/hour)** | **Relative Error** | **Dose Rate (mrem/hour)** | **Relative Error** |
| 1 | 414 | 9.7209E-03 | 0.2766 | 4.9239E-03 | 0.1224 |
| 2 | 474 | 5.5191E-03 | 0.3731 | 5.2725E-03 | 0.0810 |
| 3 | 494 | 4.2904E-03 | 0.5026 | 4.4744E-03 | 0.2389 |
| 4 | 414 | 1.1785E+00 | 0.1084 | 1.1127E+00 | 0.0596 |
| 5 | 414 | 4.1287E-01 | 0.3779 | 3.7940E-01 | 0.1846 |
| 6 | 414 | 2.8523E-01 | 0.5583 | 3.1708E-01 | 0.2133 |
| 7 | 474 | 3.6345E-01 | 0.3986 | 4.0578E-01 | 0.2172 |
| 8 | 474 | 2.7897E-01 | 0.2185 | 2.8357E-01 | 0.1281 |
| 9 | 494 | 1.2727E-01 | 0.2747 | 1.1714E-01 | 0.2201 |
| 10 | 204 | 2.3410E+00 | 0.0160 | 2.7668E+00 | 0.0100 |
| 11 | 604 | 4.4624E-01 | 0.0174 | 5.3065E-01 | 0.0111 |
| 12 | 204 | 9.3327E-01 | 0.0563 | 1.8644E+00 | 0.0937 |
| 13 | 604 | 7.2254E-02 | 0.0749 | 1.2435E-01 | 0.0388 |
| 14 | 204 | 1.9969E-01 | 0.0247 | 3.0773E-01 | 0.0178 |
| 15 | 404 | 1.6181E-01 | 0.0245 | 2.4911E-01 | 0.0186 |
| 16 | 204 | 2.8971E-01 | 0.0849 | 4.8398E-01 | 0.0505 |

Table 5-4: Neutron Dose Rates

| Case No. | Tally No. | Results from Ref. (2.6) | | Results for NUHOMS®-32P | |
|---|---|---|---|---|---|
| | | **Dose Rate (mrem/hour)** | **Relative Error** | **Dose Rate (mrem/hour)** | **Relative Error** |
| 1 | 404 | 3.6003E+00 | 0.0682 | 8.8742E-01 | 0.0705 |
| 2 | 464 | 3.3536E+00 | 0.0928 | 9.3085E-01 | 0.0936 |
| 3 | 484 | 1.5273E+00 | 0.1245 | 4.8140E-01 | 0.1194 |
| 4 | 404 | 4.1430E+01 | 0.0257 | 3.1901E+01 | 0.0186 |
| 5 | 404 | 7.1997E+01 | 0.0339 | 6.1703E+01 | 0.0213 |
| 6 | 404 | 1.1224E+02 | 0.0295 | 8.6668E+01 | 0.0206 |
| 7 | 464 | 1.9222E+02 | 0.0235 | 1.7764E+02 | 0.0149 |
| 8 | 464 | 1.7316E+02 | 0.0222 | 1.8130E+02 | 0.0128 |
| 9 | 484 | 7.5274E+01 | 0.0312 | 7.6185E+01 | 0.0180 |
| 10 | 104 | 6.1917E+01 | 0.0333 | 6.0326E+01 | 0.0190 |
| 11 | 504 | 1.2156E+01 | 0.0345 | 1.2331E+01 | 0.0213 |
| 12 | 104 | 8.9584E+02 | 0.0088 | 8.8050E+02 | 0.0054 |
| 13 | 504 | 7.2781E+01 | 0.0121 | 7.2472E+01 | 0.0073 |
| 14 | 104 | 5.4534E+00 | 0.0387 | 5.2179E+00 | 0.0320 |
| 15 | 304 | 4.2280E+00 | 0.0369 | 4.2991E+00 | 0.0321 |
| 16 | 104 | 5.0867E+01 | 0.0411 | 6.3926E+01 | 0.0241 |

The results shown in Table 5.3 and Table 5.4 are based on the "analyzed" neutron source and not the design basis neutron source. [redacted] The dose rates for design basis sources with axial peaking are summarized in Table 5-5.

Table 5-5: Dose Rates for NUHOMS®-32P Basket(mrem/hour)

| Case # | Direct Gamma Dose Rates (mrem/hr) | Capture Gamma Dose Rates (mrem/hr) | Neutron Dose Rates (mrem/hr) |
|---|---|---|---|
| 1 | 8.5176E+01 | 8.0112E-03 | 1.4438E+00 |
| 2 | 7.5694E+01 | 8.5784E-03 | 1.5145E+00 |
| 3 | 5.7720E+01 | 7.2798E-03 | 7.8324E-01 |
| 4 | 9.4734E+01 | 1.8104E+00 | 5.1903E+01 |
| 5 | 6.4264E+01 | 6.1728E-01 | 1.0039E+02 |
| 6 | 1.3573E+02 | 5.1589E-01 | 1.4101E+02 |
| 7 | 1.2761E+02 | 6.6020E-01 | 2.8902E+02 |
| 8 | 1.9022E+02 | 4.6137E-01 | 2.9498E+02 |
| 9 | 1.1738E+02 | 1.9059E-01 | 1.2395E+02 |
| 10 | 4.3512E+01 | 4.5016E+00 | 9.8150E+01 |
| 11 | 1.0117E+01 | 8.6337E-01 | 2.0063E+01 |
| 12 | 8.1623E+01 | 3.0334E+00 | 1.4326E+03 |
| 13 | 9.4975E+00 | 2.0232E-01 | 1.1791E+02 |
| 14 | 8.7693E-01 | 5.0068E-01 | 8.4895E+00 |
| 15 | 7.7971E-01 | 4.0530E-01 | 6.9946E+00 |
| 16 | 7.3202E+01 | 7.8744E-01 | 1.0401E+02 |

The results shown in Table 5.3 and Table 5.4 are based on the "analyzed" neutron source and not the design basis neutron source. [redacted] The dose rates for design basis sources with axial peaking are summarized in Table 5-5.

Table 5-6: Comparison of Neutron and Gamma Dose Rates (mrem/hour)

| Case # | 24-P Basket | | 32-P Basket | |
|---|---|---|---|---|
| | Gamma Dose Rates (mrem/hr) | Neutron Dose Rates (mrem/hr) | Gamma Dose Rates (mrem/hr) | Neutron Dose Rates (mrem/hr) |
| 1 | 7.6280E+01 | 3.6003E+00 | 8.5184E+01 | 1.4438E+00 |
| 2 | 7.0917E+01 | 3.3536E+00 | 7.5703E+01 | 1.5145E+00 |
| 3 | 5.6512E+01 | 1.5273E+00 | 5.7727E+01 | 7.8324E-01 |
| 4 | 9.5886E+01 | 4.1430E+01 | 9.6544E+01 | 5.1903E+01 |
| 5 | 6.2598E+01 | 7.1997E+01 | 6.4881E+01 | 1.0039E+02 |
| 6 | 1.3663E+02 | 1.1224E+02 | 1.3625E+02 | 1.4101E+02 |
| 7 | 1.2121E+02 | 1.9222E+02 | 1.2827E+02 | 2.8902E+02 |
| 8 | 1.7556E+02 | 1.7316E+02 | 1.9068E+02 | 2.9498E+02 |
| 9 | 1.0014E+02 | 7.5274E+01 | 1.1757E+02 | 1.2395E+02 |
| 10 | 7.2100E+01 | 6.1917E+01 | 4.8014E+01 | 9.8150E+01 |
| 11 | 1.6936E+01 | 1.2156E+01 | 1.0980E+01 | 2.0063E+01 |
| 12 | 1.3428E+02 | 8.9584E+02 | 8.4656E+01 | 1.4326E+03 |
| 13 | 1.5778E+01 | 7.2781E+01 | 9.6998E+00 | 1.1791E+02 |
| 14 | 1.0339E+00 | 5.4534E+00 | 1.3776E+00 | 8.4895E+00 |
| 15 | 9.0559E-01 | 4.2280E+00 | 1.1850E+00 | 6.9946E+00 |
| 16 | 6.3172E+01 | 5.0867E+01 | 7.3989E+01 | 1.0401E+02 |

The total dose rates predicted during loading and transfer are summarized in Table 5-7. The total dose rates for NUHOMS®-32P are compared with those for the NUHOMS®-24P (both the Ref. [2.6] values and Ref. [2.7] values) in Table 5-7.

Table 5-7: Comparison of Total Dose Rates (mrem/hour)

| Case # | NUHOMS-24P (USAR Values) (mrem/hr) | NUHOMS-24P (Ref. [2.6] Values) (mrem/hr) | NUHOMS-32P Values (mrem/hr) |
|---|---|---|---|
| 1 | 38.00 | 79.88 | 86.63 |
| 2 | 41.40 | 74.27 | 77.22 |
| 3 | 10.40 | 58.04 | 58.51 |
| 4 | 100.00 | 137.32 | 148.45 |
| 5 | 192.00 | 134.59 | 165.27 |
| 6 | 2527.00 | 248.87 | 277.25 |
| 7 | 66.70 | 313.43 | 417.29 |
| 8 | 130.60 | 348.72 | 485.66 |
| 9 | 75.30 | 175.41 | 241.52 |
| 10 | 83.60 | 134.02 | 146.16 |
| 11 | 13.00 | 29.09 | 31.04 |
| 12 | 977.00 | 1030.12 | 1517.23 |
| 13 | 163.75 | 88.56 | 127.61 |
| 14 | 33.80 | 6.49 | 9.87 |
| 15 | 33.80 | 5.13 | 8.18 |
| 16 | 62.30 | 114.04 | 178.00 |

## 6.0 Summary and Conclusions

The results of the MCNP calculations for the NUHOMS®-32P basket show that the dose rates are generally lower than expected in comparison to those for the NUHOMS®-24P basket. PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390

PROPRIETARY INFORMATION WITHHELD UNDER 10CFR2.390